11-16-00 A

Application transmittal

UTILITY PATENT APPLICATION TRANSMITTAL

(only for new non-provisional applications under 37 CFR 1.53(b))

Attorney Docket No. **Johnston 1999-0796**

First Named Inventor or Application Identifier

Title **Microphone Array for Preserving Soundfield Perceptual Cues**

Express Mail Label no. **EK508640564US**

JC571 U.S. PTO 09/713187 11/15/00

To: **Assistant Commissioner for Patents**
Box Patent Application
Washington D.C. 20231

APPLICATION ELEMENTS	ACCOMPANYING APPLICATION PARTS
☒ Fee Transmittal Form (original and duplicate)	☒ Assignment
☒ Specification Total Pages **11** title cross reference to related applications (e.g. provisional application) background summary brief description of the drawings (if filed) detailed description claims abstract	☒ Recordation form ☒ Power of Attorney ☒ Postcard ☐ Small entity statement ☐ Certified copy of priority documents ☐ Information disclosure statement ☐ Copies of IDS citations ☐ 37 CFR 3.73(b) Statement ☒ check ☐ Other
☒ Drawing(s) Total Pages **1**	
☒ Declaration Total Pages **4** a. ☐ Newly executed b. ☐ Copy from a prior application (37 CFR 1.63(d)) (for continuations/divisionals with section below filled out) ☐ Deletion of Inventor(s) Signed Statement attached deleting inventor(s) named in the prior application. 37 CFR 163 (d)(2) and 1.33(b).	
☐ Incorporation by reference (usable if Declaration is a copy): The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied, is considered as being part of the disclosure of the accompanying application is hereby incorporated by reference herein.	
☐ Other	

If a CONTINUING APPLICATION, check appropriate box and supply the requisite information:

☐ Continuation ☐ Divisional ☐ Continuation-in-part (CIP) of prior Application No:

CORRESPONDENCE ADDRESS

☐ Customer Number or Bar Code Label	(insert Customer No or Attach bar code label here)	☒ Correspondence Address below

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SIGNATURE OF APPLICANT ATTORNEY, OR AGENT

Name	**Henry T. Brendzel**	Reg. No.	**26,844**
Telephone	**(973) 467-2025**		
Signature	Henry Brendzel	Date	11/15/00

I hereby certify that this Application is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and is addressed to the Assistant Commissioner for Patents, Washington D.C. 20231.

11/15/00	**Henry Brendzel**	Henry Brendzel
Date of Deposit	(Printed Name of Person Mailing Paper)	(Signature of Person Mailing Paper)

FEE TRANSMITTAL

Patent Fees are subject to annual revisions on October 1
These are the fees effective November 10, 1998
Small entity payments must be supported by a small entity statement, Otherwise, large entity fees must be paid. See Forms PTO/SB/09-12.

TOTAL AMOUNT OF PAYMENT	($) 768

Complete if Known	
Application Number	**60/172,967**
Filing Date	**12/21/99**
First Named Inventor	
Examiner Name	
Group/Art Unit	
Attorney Docket ID	**Johnston 1999-0796**

METHOD OF PAYMENT (check one)

1. The Commissioner is hereby authorized to charge indicated fees and other underpayments, and credit overpayments to:

Deposit Account Number	Deposit Account Name
500732	**Henry T. Brendzel**

☒ Charge any additional Fee Required under 37 CFR 1.16 and 1.17

☐ Charge the Issue Fee Set in 37 CFR 1.18 at the Mailing of the Notice of Allowance

2. ☐ Payment enclosed:

☐ Check ☐ Money Order ☐ Other

FEE CALCULATION

1. FILING FEE

Fee Description	Fee Paid
Utility Filing Fee	710
Design Filing Fee	
Plant Filing Fee	
Reissue Filing Fee	
Provisional Filing Fee	
SUBTOTAL (1) ($)	710

2. CLAIMS

	Claims remaining	Highest Paid	Extra	Rate	Amount
Total Claims	21	20	1	18	18
Independent Claims	2	3	0	80	0
Multiply Dependent Claims			☐	270	0
SUBTOTAL (2) ($)					18

FEE CALCULATION (continued)

3. ADDITIONAL FEES

Fee Description	Fee Paid
Surcharge – late filing fee or oath	
Surcharge – late provisional filing fee or cover sheet	
Non-English specification	
For filing request for reexamination	
Requesting publication of SIR prior to Examiner action	
Requesting publication of SIR after Examiner action	
Extension for reply within the first month	
Extension for reply within the second month	
Extension for reply within the third month	
Extension for reply within the fourth month	
Extension for reply within the fifth month	
Notice of Appeal	
Filing a brief in support of an appeal	
Requesting an oral hearing	
Petition to institute a public use proceeding	
Petition to revive - unavoidable	
Petition to revive - unintentional	
Utility issue fee (or reissue)	
Design issue fee	
Plant issue fee	
Petitions to the Commissioner	
Petitions related to provisional applications	
Submission of Information Disclosure Statement	
Recording each patent assignment per property (times number of properties)	40
Filing a submission after final rejection (37 CFR1 129(a))	
For each additional invention to be examined (37 CFR 1.129(b))	
Other fee	
Other fee	
SUBTOTAL (2) ($)	40

SUBMITTED BY

Typed of Printed Name	Henry T. Brendzel			Complete (if applicable) Reg. Number	26,844
Signature	Henry Brendzel	Date	11/15/00	Deposit Account User ID	

Microphone Array for Preserving Soundfield Perceptual Cues

Related Application

This invention claim priority from provisional application No. 60/172,967, filed December 21, 1999.

Background

This invention relates to multi-channel audio origination and reproduction.

Increasing demands for realistic audio reproduction from consumers and music professionals, and the abilities of modern compression technology to store and deliver multichannel audio at bit rates that are feasible, as well as current consumer trends, show that multichannel (herein, more than two channels) sound is coming to consumer audio and the "home theater." Numerous microphone techniques, mixing techniques, and playback formats have been suggested, but a great deal of this effort has ignored the long-established requirements that have been found necessary for good perceived sound-field reproduction. As a result, soundfield capture and reproduction remains one of the key research challenges to audio engineers.

The main goal of soundfield reproduction is to reconstruct the spatial, temporal and qualitative aspects of a particular venue as faithfully as possible when playing back in the consumer's listening room. Artisans in the field understand, however, that exact soundfield reproduction is unlikely to be achieved, and probably impossible to achieve, for basic physical reasons.

There have been numerous attempts to capture the experience of a concert hall on recordings, but these attempts seem to have been limited primarily to the idea of either co-incident miking, which discards the interaural time difference, or widely spaced miking, which provides time cues that are not of the range 0 to ± 0.9 msec, and thus provide cues that are either not expected by the auditory system or constitute contradictory information. The one exception appears to be binaural miking methods, and their derivatives, which do two-channel recording and which attempt to take some account of human head shape and perception, but which create difficulties both in the matching of the "artificial head" or other recording mount, and which do not allow the listener to sample the soundfield by

small head movements. (Listeners unconsciously use small head movements to sample soundfields in normal listening environments.)

In the realm of multichannel audio, current mixing methods consist of either co-incident miking (ambiphonics) or widely spaced miking (the purpose being to de-correlate the different recorded channels), neither of which provides both the amplitude and time cues that the human auditory system expects.

Summary of the Invention

Rather than capturing, and later reproducing, the exact soundfield, the principles disclosed herein undertake to reconstruct the *listener-perceived* soundfield. This is achieved by capturing the sound using a set of directional microphones that lie approximately on a sphere having a diameter of 0.9 ms sound travel. The 0.9 ms sound distance approximates the inter-aural time delay. Advantageously, one directional microphone points upward, one directional microphone points downward, and the remaining microphones (e.g., five of them) are arranged relatively evenly in the horizontal plane. On one embodiment, the signals from the microphones that point upward and downward are combined with the signals of the horizontal microphones before the signals of the horizontal microphones are recorded.

Brief Description of the Drawings

FIG. 1 presents an arrangement of microphones in accord with the principles of disclosed herein; and

FIG. 2 illustrates a microphone sensitivity pattern of microphones used in the FIG. 1 arrangement.

Detailed Description

In connection with human perception of the direction and distance of sound sources, a spherical coordinates system is typically used. In this coordinate system, the origin lies between the upper margins of the entrances to the listener's two ear canals. The horizontal plane is defined by the origin and the lower margins of the eye sockets. The frontal plane is at right angles to the horizontal plane and intersects the upper margins of

the entrances to the ear canals. The median plane (median sagittal plane) is at right angles to both the horizontal and frontal planes. In the context of this coordinate system, the angular position of an auditory event is described by γ, which is the distance between the auditory event and the center of origin; θ, which is the azimuth angle; and δ, which is the elevation angle.

Two cues provide the primary information for determining the angular position, γ, of a source. These are the *interaural time difference* and the *interaural level difference* between the two ears. The direction from where the sound is perceived to be coming can be rotated about the axis passing through the ear canals to create a "cone of confusion" that describes where the sound may come from. The localization to the cone of confusion can be done by either time or level cues, or both. At low frequencies, the interaural time difference is directly detectable by the human auditory system. At frequencies above 2kHz to 3kHz, this ability to synchronously detect the differences disappears, and the listener must rely, for time-stationary signals, on level differences created by the HRTF. For non-stationary signals that include a "leading edge", however, the ear is capable of using the envelope of the signal as an interaural time difference cue, allowing both time and level cues even at high frequencies.

Most of the interaural level difference lies in the effect of the diffraction of the sound wave around the listener's head. The sound shadow caused by the head is particularly important when the sound's wavelength is close to, or smaller than, the size of the head. Hence, the interaural level difference is frequency dependent; the shorter the wavelength (the higher the frequency), the greater the sound shadow and hence the larger the interaural level difference. As a result, interaural level difference works particularly well at high frequencies and is the main directional cue at high frequencies for signals with stationary energy envelopes. The interaural level difference is also directionally variable in δ, varying with the position of the sound source in azimuth, which helps disambiguate the information from the "cone of confusion."

For sounds with a non-time-stationary energy envelope, the interaural time difference cue is not limited to low frequency signals detection. The ear is sensitive to the attacks and low frequency content in the envelope of complex sounds. In other words, the auditory system makes use of the interaural time difference in the temporal envelope of the

sounds in order to determine the location of a sound source.

Particularly for sounds that happen to come from within the cone of confusion, the interaural time and level cues in general are not sufficient for three-dimensional sound localization. It is the binaural spectral characteristics of the signal due to head-related transfer functions (HRTFs) that help explain the human hearing mechanism when distinguishing between sound sources located in three-dimensional space, particular those located along a cone of confusion. When sound waves propagate in space and pass the human torso, shoulders, head and the outer ears (pinnae), diffractions occur and the frequency characteristics of the audio signals that reach the eardrum are altered. The spectral alternations of the input signals in different directions are referred to as the head-related transfer functions (HRTFs) in the frequency domain and head-related impulse response (HRIR) in the time domain. Because the wavelength of high frequencies is closer to the size of those small body parts, such as head and pinna, the spectral change in sounds is mostly limited to frequency components above 2 kHz. HRTFs vary in a complex way with azimuth, elevation, range and frequency. In general they differ from person to person as the amount of attenuation at different frequencies depends on the size and shape of the objects (such as pinna, nose and head) of the individual person. Head-related transfer functions are also directionally dependent and, for example, this usually causes more high frequency attenuation from sounds coming behind a person than those coming in front of the person. In general, there is a broad maximum near the ear canal resonance, 2 - 4kHz for sound sources located in the median-sagittal plane. For frequencies above 5 kHz, the HRTFs are characterized by a spectrum notch, which occurs at a frequency varying with the position of the sound source. When the source is below, the notch appears near 6 kHz. The notch moves to higher frequencies when the source is elevated. However, when the source is overhead, the HRTF has a relatively flat spectrum and the notch disappears. In this invention, the system advantageously uses, for the horizontal plane, the HRTF of the listening individual to a much greater extent than "auralization" techniques. If a situation exists where the placement of "up" and "down" loudspeakers exists, it would also be preferential to use same, however most consumer situations prevent this extension of the techniques from being practical at the present time.

With this knowledge about the human auditory system, in accordance with the

principles of this invention, a sound is recorded with the notion of capturing the sound elements as they are perceived by the human auditory system.

To that end, the sound-capturing arrangement disclosed herein employs a plurality of directional microphones that are arranged on a sphere having a diameter that approximately equals the distance that corresponds to the time that it takes a sound to travel from one ear to the other (approximately 0.9 msec). In this disclosure, this distance is referred to as the interaural sound delay.

FIG. 1 depicts one embodiment of a sound recording arrangement in accord with the principles disclosed herein. It includes seven microphones that are positioned in space to lie on a sphere 10. These microphones are each directional microphones that will capture the sound from a particular direction, with the time delay between microphones being determined by the effective location of the microphone capsule inside the microphone body. Sphere 10 is not a physical element, of course. It is just a convenient means for describing the spatial position of the microphones. The origin of the sphere lies in the above-mentioned horizontal plane, which in FIG. 1 is labeled 20. One of the microphones, 31, is positioned to point upward, basically perpendicular to the horizontal plane; and another of the microphones, 32, is positioned to point downward, also basically perpendicular to the horizontal plane. The remaining microphones are arranged along the intersection of the horizontal plane and the sphere (which is a great circle). One of those microphones faces the direction that is considered the "front" (the direction at which a listener would be facing, if the listener were to replace the microphones), and the remaining microphones are arranged symmetrically about the midline. With five microphones facing horizontally, an acceptable arrangement places the microphones 72° apart. With seven microphones facing horizontally, an acceptable arrangement is ±45°, ±90°, and ±150°. Although again, a center-front equal spacing will provide good results as well.

The number of microphones used is not critical. One can use, for example, the five horizontally-facing microphones employed in the FIG. 1 arrangement, without the "up" and "down" microphones. Of course, the performance would suffer because these microphones detect the reflections off the ceiling and floor, respectively, and those reflections are significant contributors to spatial effects and to the sense of distance. It is

advantageous, though, to have an odd number of microphones that face horizontally, with one facing the front, as mentioned above. It is also marginally acceptable to use fewer than five, and desirable to use more than five, microphones in the horizontal plane, if the consumer deliver mechanisms exist. A minimum of three microphones, aimed to the front of the listener, are required in any case, meaning that one microphone is directed at the direction at which a listener would be facing, and the other two microphones are aimed at angles $\pm\alpha<90°$ away from that direction, such as with angles $\pm\alpha<30°$ or $\pm\alpha<45°$.

FIG. 1 depicts distinct directional microphones 31 through 37 but, actually, it has been found that the reception pattern of those microphones is what plays a more important role than the number of microphones, and if the desired pattern is best realized with a collection of individual microphones, use of such a collection is clearly acceptable. For purposes of this disclosure, in fact, such a collection is considered as a single microphone.

As for the desirable reception pattern, it can be like the one depicted in FIG. 2. This pattern is characterized by a primary (front) lobe that is down 3db by at a direction of the immediately neighboring microphone, and is down to effectively zero at a direction of the next-most immediate neighboring microphone (e.g., more than 40db down). This pattern depicts the sensitivity of the microphone to arriving sounds. The microphone is said to point to a direction, that being the direction at which the microphone's sensitivity is greatest. Since FIG. 2 depicts the five horizontal microphones arrangement of FIG. 1 where the microphones are 72° apart, this requirement translates to a primary lobe that is down by 3 db at 72° and down to effectively zero at 144°. The microphones can also have a small back (possibly negative phase) lobe, but it is not required.

There may be occasions when it is desirable to record all of the received sound channels; that is, the signals of all seven of the FIG. 1 microphones. For example, if a listener is in a room that includes an ceiling speaker that faces down, and a floor speaker that faces up, both roughly above the listener's head and below the listener's feet, respectively, then it is most advantageous to record the signals of microphones 31-37 and to send the signal of microphone 31 to the ceiling speaker and the signal of microphone 32 to the floor speaker. Conversely, when it is expected to employ the recorded signals in a room with only five speakers, and, therefore the signals of microphones 31 and 32 need to be combined with the other five signals, then it makes more sense to combine the signals

before storing, thereby saving on storage space. Of course, if the signals are merely transmitted to a remote location, the processing (i.e., combining) of signals can be done at the remote location.

Because microphones 31 and 32 are placed appropriately for capturing the time delay according to the human head, they can be folded easily into the signals of microphones 33-37, using the equation

$$s'_{31} = s_{31} + \frac{1}{\sqrt{5}}(s_{31} + s_{32}),$$

without further processing for HRTF and delay. If a superior result is desired, one can add some processing for both mike and listener's effective HRTF's, but this has been proven in practice to be very well approximated by the simple sum of components.

1. A sound recording arrangement comprising:

a plurality of at least three microphones, with at least one pair of said microphones providing a sound time-of-arrival difference of approximately 0.9msec; and

means for communicating signals of said microphones to other equipment.

2. The arrangement of claim **1** where said means is output ports, recording apparatus, or a signal transmission apparatus.

3. The arrangement of claim **1** where said microphones are directional.

4. The arrangement of claim **5** where said plurality of directional microphones, as a group, are more sensitive to sound arriving from a front direction of said arrangement than from any other direction.

5. The arrangement of claim **3** where a majority of said microphones point to directions lying substantially on a horizontal plane.

6. The arrangement of claim **5** having at least one microphone additional microphone that is aimed at other than on said horizontal plane.

7. The arrangement of claim **5** where one of said microphones that point to directions lying on a horizontal plane points to a front direction.

8. The arrangement of claim **7** where others of said microphones that point to directions lying on a horizontal plane are paired up, and each pair j is pointed to directions $\pm\alpha_i$, where $\alpha_i \neq \alpha_j$ when $i \neq j$.

9. The arrangement of claim **8** where sensitivity of a microphone that points at direction α_I has a sensitivity at direction $\alpha_{I\pm1}$ that is down 3 db from said sensitivity at direction α_I, and said sensitivity of a microphone that points at direction α_I has a sensitivity at direction $\alpha_{I\pm2}$ that is more than 40db down from said sensitivity at direction α_I.

10. The arrangement of claim **1** where said microphones are situated at effective positions in space that lie on a surface that approximates a sphere.

11. The arrangement of claim **10** where said sphere has a diameter that corresponds to a time of sound travel of approximately 0.9msec.

12. The arrangement of claim **1** where said a plurality of at least three microphones comprises a plurality of at least three microphones that point to directions on a horizontal plane, and an additional microphone that points at a direction that is substantially perpendicular to said horizontal plane.

13. The arrangement of claim **12** where said additional microphone points downward from said horizontal plane, or upward from said horizontal plane.

14. The arrangement of claim **1** where said a plurality of at least three microphones comprises a plurality of at least three microphones that point at directions substantially on a horizontal plane, one additional microphone that points at a direction that is substantially perpendicular and upward from said horizontal plane, and another additional microphone that points at a direction that is substantially perpendicular and downward from said horizontal plane.

15. The arrangement of claim **14** further comprising a storage medium coupled to said means for communicating signals of said microphones to other equipment, for storing in a separate area the signals of each of said plurality of microphones.

16. The arrangement of claim **14** further comprising a processor for combining selected ones of said signals of said plurality of at least three microphones.

17. The arrangement of claim **16** where said processor develops a modified signal

$s_h' = s_h + \frac{1}{\sqrt{N}}(s_u + s_d)$, for each signal s_h of a microphone from said plurality of at least three microphones that points at a direction that lies substantially on said horizontal plane, where s_u is the signal of said microphone that points substantially upward relative to said horizontal place, and said s_d is the signal of said microphone that points substantially downward relative to said horizontal place.

18. The arrangement of claim **1** where said plurality of at least three microphones comprises an odd number of microphones that point to directions that lie substantially on a horizontal plane.

19. The arrangement of claim **18** where said plurality of at least three microphones comprises five microphones that point to directions 0°, ±72°, and ±144°.

20. The arrangement of claim **18** where said plurality of at least three microphones comprises seven microphones that nominally point to directions 0°, ±45°, ±90°, and ±150°.

21. An arrangement to reproduce sound from a plurality of channels, comprising:

an N plurality of input ports for receiving signals picked up by an N plurality of microphones, where one of said microphones points at a direction that is substantially perpendicular to and upward from a horizontal plane and picks up signal s_u, another of said microphones points at a direction that is substantially perpendicular to and downward from said horizontal plane and picks up signal s_d, and remaining N-2 of said microphones point at directions that substantially lie in said horizontal plane and pick up signals s_h'; and

a processor for developing signals s_h'', i=1, 2,... N-2, such that

$$s_h' = s_h' + \frac{1}{\sqrt{N}}(s_u + s_d).$$

Abstract

A sound-capturing arrangement uses a set of directional microphones that lie approximately on a sphere having a diameter of 0.9 ms sound travel, which approximates the inter-aural time delay. Advantageously, one directional microphone points upward, one directional microphone points downward, and the odd number of microphones are arranged relatively evenly in the horizontal plane. On one embodiment, the signals from the microphones that point upward and downward are combined with the signals of the horizontal microphones before the signals of the horizontal microphones are transmitted or recorded.

FIG. 1

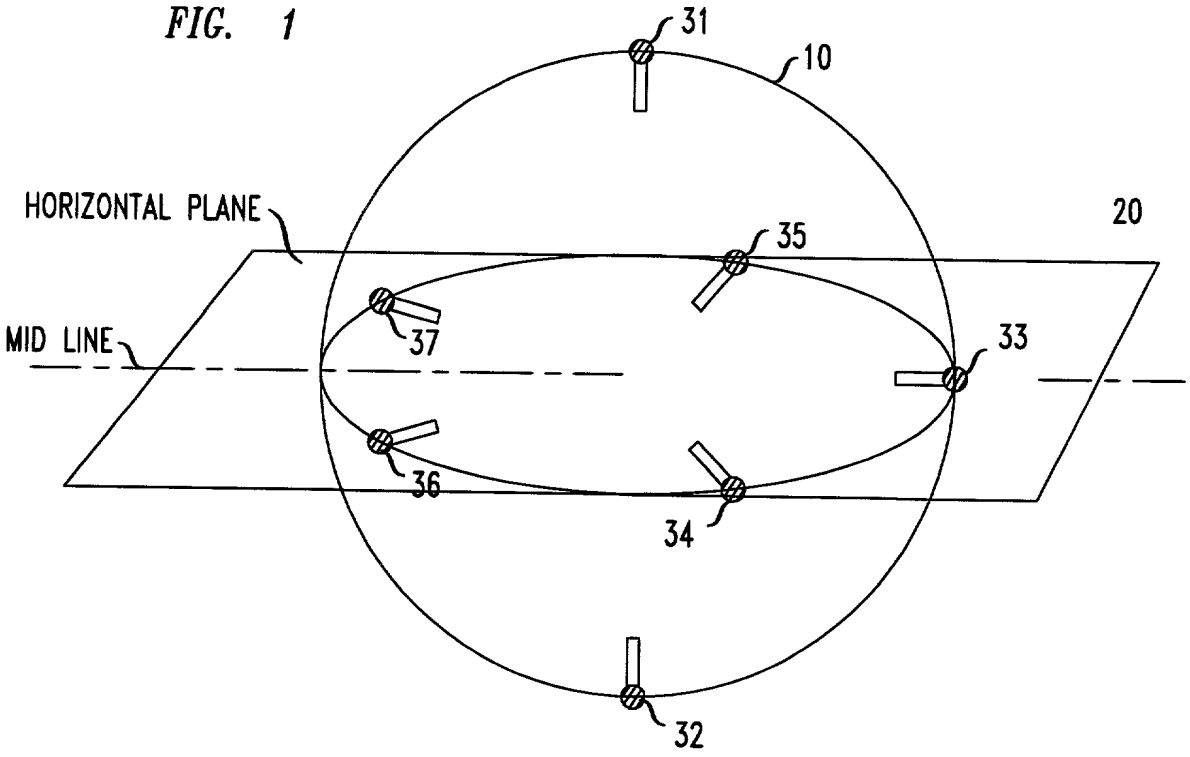
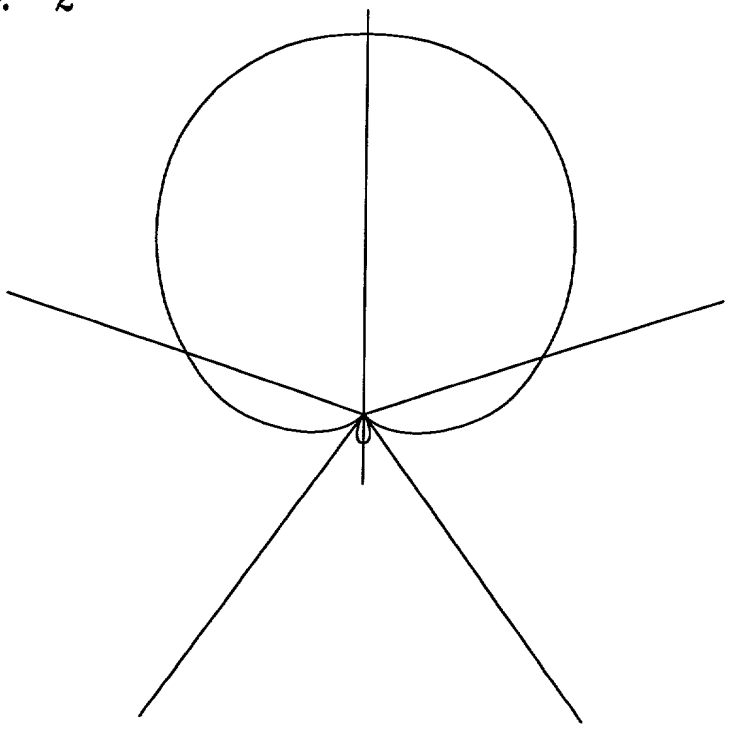


FIG. 2



IN THE UNITED STATES
PATENT AND TRADEMARK OFFICE

Declaration and Power of Attorney

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am an original, first and joint inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled **Microphone Array for Preserving Soundfield Perceptual Cues** the specification of which was filed on 12/21/99, as application Serial No. 60/172,967.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by an amendment, if any, specifically referred to in this oath or declaration.

I acknowledge the duty to disclose all information known to me, which is material to patentability as defined in Title 37, Code of Federal Regulations, 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, 119 of any foreign application(s) for patent or inventors' certificate listed below and have also identified below any foreign application for patent or inventors' certificate having a filing date before that of the application on which priority is claimed:

None

I hereby claim the benefit under Title 35, United States Code, 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, 112, we acknowledge the duty to disclose all information known to us to be material to patentability as defined in Title 37, Code of Federal Regulations, 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

None

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

I hereby appoint the following attorney(s) with full power of substitution and revocation, to prosecute said application, to make alterations and amendments therein, to receive the patent, and to transact all business in the Patent and Trademark Office connected therewith:

Samuel H. Dworetsky	(Reg. No. 27873)	Thomas A. Restaino	(Reg. No. 33444)
Michele L. Conover	(Reg. No. 34962)	Cedric G. DeLaCruz	(Reg. No. 36498)
Rohini K. Garg	(Reg. No. 45272)	Thomas M. Isaacson	(Reg. No. 44166)
Benjamin S. Lee	(Reg. No. 42787)	Robert B. Levy	(Reg. No. 28234)
Susan E. McGahan	(Reg. No. 35948)	Gary H. Monka	(Reg. No. 35290)
Jeffrey M. Navon	(Reg. No. 32711)	Stephen K. Pentlicki	(Reg. No. 40125)
Alfred G. Steinmetz	(Reg. No. 22971)		

I also appoint the following as associate attorney(s), with full power to prosecute said application, to make alternations and amendments therein, and to transact all business in the Patent and Trademark Office connected therewith:

Henry T. Brendzel (Reg. No. 26,844)
William Ryan (Reg. No. 26,844)

Please address all correspondence to Henry T. Brendzel, P.O. Box 574, Springfield, NJ 07081. Telephone calls should be made to Henry T. Brendzel at (973) 467-2025.

Full name of joint inventor: James David Johnston

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Morristown, NJ 07960

Full name of joint inventor: Eric R. Wagner

Inventor's signature Eric R. Wagner Date 11-8-2000
Residence: South Plainfield, Middlesex County, NJ
Citizenship: USA
Post Office Address: 400 Rahway Avenue
South Plainfield, NJ 07081

IN THE UNITED STATES
PATENT AND TRADEMARK OFFICE

Declaration and Power of Attorney

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am an original, first and joint inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled **Microphone Array for Preserving Soundfield Perceptual Cues** the specification of which was filed on 12/21/99, as application Serial No. 60/172,967.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by an amendment, if any, specifically referred to in this oath or declaration.

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None

I hereby claim the benefit under Title 35, United States Code, 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, 112, we acknowledge the duty to disclose all information known to us to be material to patentability as defined in Title 37, Code of Federal Regulations, 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

None

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

I hereby appoint the following attorney(s) with full power of substitution and revocation, to prosecute said application, to make alterations and amendments therein, to receive the patent, and to transact all business in the Patent and Trademark Office connected therewith:

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